PB-238 077

BACKGROUND INFORMATION FOR STANDARDS OF PERFORMANCE: ELECTRIC SUBMERGED ARC FURNACES FOR PRODUCTION OF FERROALLOYS. VOLUME 2. TEST DATA SUMMARY

ENVIRONMENTAL PROTECTION AGENCY

OCTOBER 1974

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16. ABSTRACT

This volume is the first in a series on the standard of performance for electric submerged arc furnaces producing ferroalloys. This volume provides background information and the rationale used in the development of the proposed standard of performance. The economic and environmental impacts of the standard are discussed.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

October 1974

1-A

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INTRODUCTION

This report summarizes the source test results and visible emission measurements cited in Background Information for Standards of Performance: Electric Submerged Arc Furnaces for Production of Ferroalloys, Volume 1, Proposed Standards. This volume describes the tested facilities (their operating conditions, characteristics of the exhaust gas streams, and deviations from prescribed test procedures) and summarizes the results of the particulate matter and carbon monoxide tests.

Facilities are identified by the same coding used in Volume 1. For example, Table 1 summarizes results of the August 1972 tests of an electric submerged arc furnace producing ferromanganese, Facility A1. These same results are also plotted as Furnace A1 in Figure VI-1 of Volume 1.

Many of the tests summarized herein were conducted using EPA Reference Method 5 for determination of particulate matter from stationary sources. In these cases, additional measurements were made to evaluate materials that condense and are collected in the impingers as the gases are cooled. In the summaries, the "probe and filter catch" is the particulate emission measurement used in the figures in Volume 1, and is the basis of the standard. The "total catch" includes the probe and filter catch plus material collected in the impingers.

Note: Any reference in this report to commercial products by name does not constitute an endorsement of the product by the Environmental Protection Agency.

The other known test method used, the Japanese Industrial Standard test method, does not use impingers.* Particulate matter is collected on a filter having a collection efficiency of 99 percent. In this sense, the particulate catch is analogous to the "probe and filter catch" of EPA Reference Method 5.

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*Japanese Industrial Standards Association, "Methods of Measuring Dust Content in Stack Gas," JIS Z 8808-1970.

Summary of Test Data

A program was undertaken by EPA to evaluate the best particulate matter control techniques available for controlling emissions from electric submerged arc (ESA) furnaces producing ferroalloys and calcium carbide. The data obtained serve as the basis for standards of performance for ferroalloy furnaces being proposed under section 111 of the Clean Air Act as amended. Fourteen ESA furnaces with air pollution control were tested using EPA Method 5 for determination of particulate matter. These data are supported by reported emission data from seven additional electric submerged arc furnace facilities. Visible emission data were obtained for two additional ESA furnaces with air pollution control. Additional background information was available from the EPA-TFA joing study of atmospheric emissions from the ferroalloy industry.

Of the fourteen controlled furnaces tested using Method 5, seven were open furnaces, two were semi-enclosed, and five were sealed. A variety of control systems were used on these furnaces. Data reported by ferroalloy producers represent emissions from wet scrubber or wet scrubber and electrostatic precipitator control systems.

All data are graphed for visual comparison in Figures 1 through 6.

Description of Facilities

A1. Sealed electric submerged arc furnace producing ferromanganese, 30 MW design capacity, equipped with two identical, parallel, three-stage

Warkaus venturi systems. Only one of the parallel venturi systems was operated during this test series. Water flowrate to the venturi was approximately 225 gallons per minute. Water was not recirculated to the scrubber. No fan is used for the venturi system. Aspiration of gases is provided by water injection at the venturi. Average furnace power input during the test periods was 26 MW. Tested by EPA using Method 5 with the single exception that the probe was not heated.

A2. Sealed electric submerged arc furnace producing ferromanganese. This is the same facility as A1 except tests were performed with both the parallel venturi systems operating. Average furnace power input during the test periods was 27 MW. Tested by EPA using Method 5 with the single exception that the probe was not heated.

B. Sealed electric submerged arc furnace, producing silicomanganese, 27 MW design capacity, equipped with a venturi type gas conditioner followed by a series venturi scrubber. The gas conditioning venturi operated at about two inches of water pressure drop. The second (series) venturi operated at a pressure drop of approximately 50 inches of water. River water was used for the scrubbers and was not recirculated. Combined water flowrate to both venturis was estimated as 355 gallons per minute. Average furnace power input during the test periods was 23 MW. Tested by EPA using Method 5 with the single exception that the probe was not heated.

C. Semi-enclosed electric submerged arc furnace producing calcium carbide, 24 MW design capacity, equipped with a Buffalo Forge centrifugal

type scrubber. Scrubber water flowrate was 450 gallons per minute. Average furnace power input during the test periods was 23.8 MW. Tested by EPA using Method 5 with the exception that sampling was performed at only one point (stack center). Fumes emitted from the annular spaces around the electrodes are captured by secondary hoods and emitted uncontrolled to the atmosphere. These emissions were measured using EPA Method 5 except that sampling times were less than two hours. Tapping fumes are also captured in a hood to be emitted uncontrolled to the atmosphere. The tapping fumes were measured using EPA Method 5 except that only one traverse direction was used and sampling time was less than 2 hours.

D. Sealed electric submerged arc furnace producing ferromanganese, 25 MW design capacity, equipped with two identical parallel venturi systems followed by a common series 25,000 kilovolt wet electrostatic precipitator. One of the two parallel venturi systems is normally operated while the other is used as a standby system. Each of the parallel venturi systems consists of a primary and secondary venturi scrubber in series. Pressure drop across each venturi is approximately 10 inches of water and water flowrate to each venturi is 160 gallons per minute. Water flowrate to the electrostatic precipitator is 160 gallons per minute. Tested by the company using the Japanese Industrial Standard test method.

E. Sealed electric submerged arc furnace producing ferromanganese. Average furnace power input is 25 MW. The air pollution control system consists of six parallel shaft kilns each followed by a series venturi

scrubber which then manifold the gas stream in common to series Thiesen scrubber followed by a series demister. Pressure drop across each venturi is approximately 12 inches of water. Tested by the company using the Japanese Industrial Standard test method.

F. Sealed electric submerged arc furnace producing silicomanganese. Average furnace power input is 29 MW. The air pollution control system and test method are identical to those for furnace E.

G. Closed top electric submerged arc furnace for the production of 45 percent ferrosilicon. Calculated furnace size is 17 MW.* The air pollution control system consists of a wet inclined duct, a scrubber, and an atomizing pipe with a 3.5 inch diameter throat. Total system water flowrate is 185 gallons per minute at a system pressure drop of 80 inches of water. Test method is unknown.

H. Sealed electric submerged arc furnace for the production of 75 percent ferrosilicon. Average furnace power input is 12 MW. The furnace is equipped with two parallel venturi scrubbers followed by a common series mist eliminator. Total water flowrate is approximately 500 gallons per minute and the pressure drop across each venturi is approximately 12 inches of water. Tested by the company using the Japanese Industrial Standard test method.

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*Dobryakov, G. G., Serebryakov, M. Z., and Rychkov, V. P., "Operation of a Gas Cleaning System on a Closed Top Electric Furnace," Steel in the U.S.S.R., Page 2, May, 1971.

I. Sealed electric submerged arc furnace for the production of ferrochrome silicon. The furnace is designed for operation at 26 MW, and is equipped with two series venturi scrubbers followed by a mist eliminator. Total pressure drop across both venturi scrubbers is approximately 58 inches of water. Total water flowrate to both venturi scrubbers is approximately 400 gallons per minute. Tested by the company using the Japanese Industrial Standard test method.

J. Sealed electric submerged arc furnace for the production of 50 percent ferrosilicon. The furnace is designed for operation at 25 MW, and is equipped with two series venturi scrubbers followed by a series mist eliminator and a series wet electrostatic precipitator. Water flowrate to each venturi and to the electrostatic precipitator is approximately 100 gallons per minute. Pressure drops across the first and second venturi are approximately 12 and 24 inches of water, respectively. Tested by the company using the Japanese Industrial Standard test method.

K. Sealed electric submerged arc furnace producing 50 percent ferrosilicon. The furnace is designed to operate at 42 MW. During testing, the furnace operated at an average of 31 MW. The air pollution control system is the same type as for furnace J. Tested by EPA using Method 5 with the exception that only the filter was heated.

L1. Open electric submerged arc furnace producing silicomanganese. Furnace load during the tests averaged 25.1 MW. The air pollution control system consists of a hood and two parallel venturi scrubbers

exhausting to a single stack. Venturi pressure drop was 57 inches water gauge. Between 1160 and 1260 gallons per minute of scrubber water was supplied to each scrubber. Tested by EPA using Method 5 except that sampling was done only on one stack diameter and two of 18 traverse points could not be reached by the probe.

L2. The same furnace and test method as in L1 above. Scrubber pressure drop was 47 inches water gauge and average furnace power load was 27.3 MW during these tests.

L3. The same furnace and test method as in L1 and L2 above. Scrubber pressure drop was 37 inches water gauge and average furnace power load was 27.5 MW during these tests.

M. Open 17 MW, Packet-type electric submerged arc furnace producing silicon metal. The air pollution control system consists of three parallel open pressure baghouses having monitor discharges. Samples were collected using four EPA Method 5 particulate trains operated simultaneously, each measuring emissions from 1/4 of the baghouse monitor area. Three of these areas were sampled at 6 "traverse" points, while the fourth was only sampled at 2 "traverse" points because of unavailability of a longer probe. Sampling was not isokinetic. Because of a leak in one bag in one compartment, test results for the train using only two traverse points were high and were omitted. Each baghouse has open grates at the tube sheet level to allow ambient air to circulate and cool the bags. Air thermally induced through these grates was measured in every other compartment of all three baghouses using rotary vane anemometers, and

total induced air flow was estimated. Total inlet gas flow from the furnace to the three baghouses was also measured. Five percent of the total inlet gas flow was found to result from leakage of fume from a second silicon furnace past a closed damper into the control system. Particulate matter emissions for each run were obtained as the product of the average grain loading resulting from emissions from the one baghouse and the total gas flow to the three baghouses.

N. Open, 7-9 MW nominal capacity electric submerged arc silicomanganese furnace. Furnace load during the tests was 7.2 MW. The air pollution control system consists of a furnace hood, a tapping hood having an estimated capture efficiency of 20 percent, and an Aeronetics scrubber. Fume from both the furnace and tapping hood is discharged through the scrubber. Scrubbing water was supplied at 82 gallons per minute. Tested by EPA using Method 5 except that only 24 traverse points were used instead of 36 as called for by standard criteria.

O. Open 36 MW nominal capacity electric submerged arc furnace producing 75 percent ferrosilicon. During testing, the furnace load averaged 22.3 MW. The air pollution control system consists of a hood, settling chamber, and closed pressure bag filter with three stacks. Tested by EPA using Method 5 except that the probe and filter were not heated. Sampling was performed on one stack only, and air flows were measured on the other two stacks. Total emissions were calculated as the product of particulate concentrations as determined on one stack and total air flow to the baghouse.

P. Semi-enclosed, 40-50 MW nominal capacity electric submerged arc furnace producing 50 percent ferrosilicon. Average furnace load during the tests was 46.5 MW. Air pollution control is achieved using two parallel venturi scrubbers operating at pressure drops of 70-80 inches water gauge. Water flow rates are 302 gallons per minute and 422 gallons per minute to the two scrubbers, respectively. Both scrubbers exhaust to a common stack where the gas is flared. Tested by EPA using Method 5 except that the probe and filter were not heated and separate test trains were used for traverses along each of the two axes. Fumes emitted through the annular spaces around the electrodes are captured by a secondary hood and passed directly to the atmosphere. These fumes were measured using EPA Method 5. Tapping fumes are also caught in a hood to be emitted uncontrolled to the atmosphere. The tapping fumes were measured using EPA Method 5 except that only one traverse direction was used. Tests of the fumes emitted through the annular spaces around the electrodes and from tapping were conducted about 5 months before tests of the emissions from the venturi scrubbers' exhaust stack.

Q. Open electric submerged arc furnace producing ferrochrome silicon. The furnace load was 20 MW during the tests. Air pollution control is by a hood, spark arrestor, indirect air cooler, and an open pressure baghouse with a monitor discharge. Tested by EPA using Method 5 except that sampling was not isokinetic, and samples were obtained simultaneously by three trains, each evenly spaced along the length of the monitor and each sampling at one point throughout the test.

R. Sealed, 26 MW nominal capacity electric submerged arc furnace producing ferrochrome silicon. During tests, the average furnace load was 18.6 MW. Two venturi scrubbers and a wet cyclone in series provide air pollution control. Venturi pressure drops are about 8 and 80 inches water gauge, respectively for the first and second venturis. Tested by EPA using Method 5 except that the probe was not heated, the filter was heated only during runs 2 and 3, and it was necessary to split the test train by fastening the filter holder to the end of the probe and connecting the filter to the impingers with a flexible tube.

S. Sealed, electric submerged arc furnace producing high carbon ferrochrome. The average furnace load during the tests was 18.0 MW. A closed suction baghouse and flare are used for air pollution control. Tested using EPA Method 5 except that the probe and filter were not heated.

T. Open, 40 MW nominal capacity electric submerged arc furnace producing high carbon ferrochrome. The average furnace load during the tests was 32.7 MW. The air pollution control system consists of a furnace hood, a separate tapping hood having an estimated collection efficiency of 80 percent, a gas conditioning tower, and a 78,000 volt electrostatic precipitator. Fume from both the furnace and tapping hood is discharged through the precipitator. Tested by EPA using Method 5.

U. Tightly hooded open furnace producing high carbon ferrochrome. During tests, the furnace power load averaged 15.0 MW. The air pollution

control system consists of the furnace hood, an efficient tapping hood, and a closed pressure bag filter with three stacks. Fume from both the furnace and the tapping hood are exhausted to the bag filter. Tested by EPA using Method 5. Sampling was performed on one stack only, and air flows were measured on the other two stacks. Total emissions were calculated as the product of particulate concentration as measured on one stack and total air flow through all three stacks.

V. Open, 20 MW nominal capacity electric submerged arc furnace producing silicomanganese. Only visible emission readings were obtained at this facility. The average furnace load during the readings was about 18 MW. The air pollution control system consists of a hood, a separate tapping hood, and an open pressure baghouse having a monitor discharge. Fume from both the furnace and tapping hood is discharged through the baghouse.

W. Open, 19 to 21 MW electric submerged arc furnace producing silicon metal. Only visible emission readings were obtained at this facility. The average furnace load during the readings was about 19.5 MW. The air pollution control system consists of a hood, a separate tapping hood, a set of hairpin gas coolers, and an open pressure baghouse having a monitor discharge. Fume from the tapping hood is discharged beneath the furnace hood where it is captured and conducted to the baghouse with the rest of the fume.

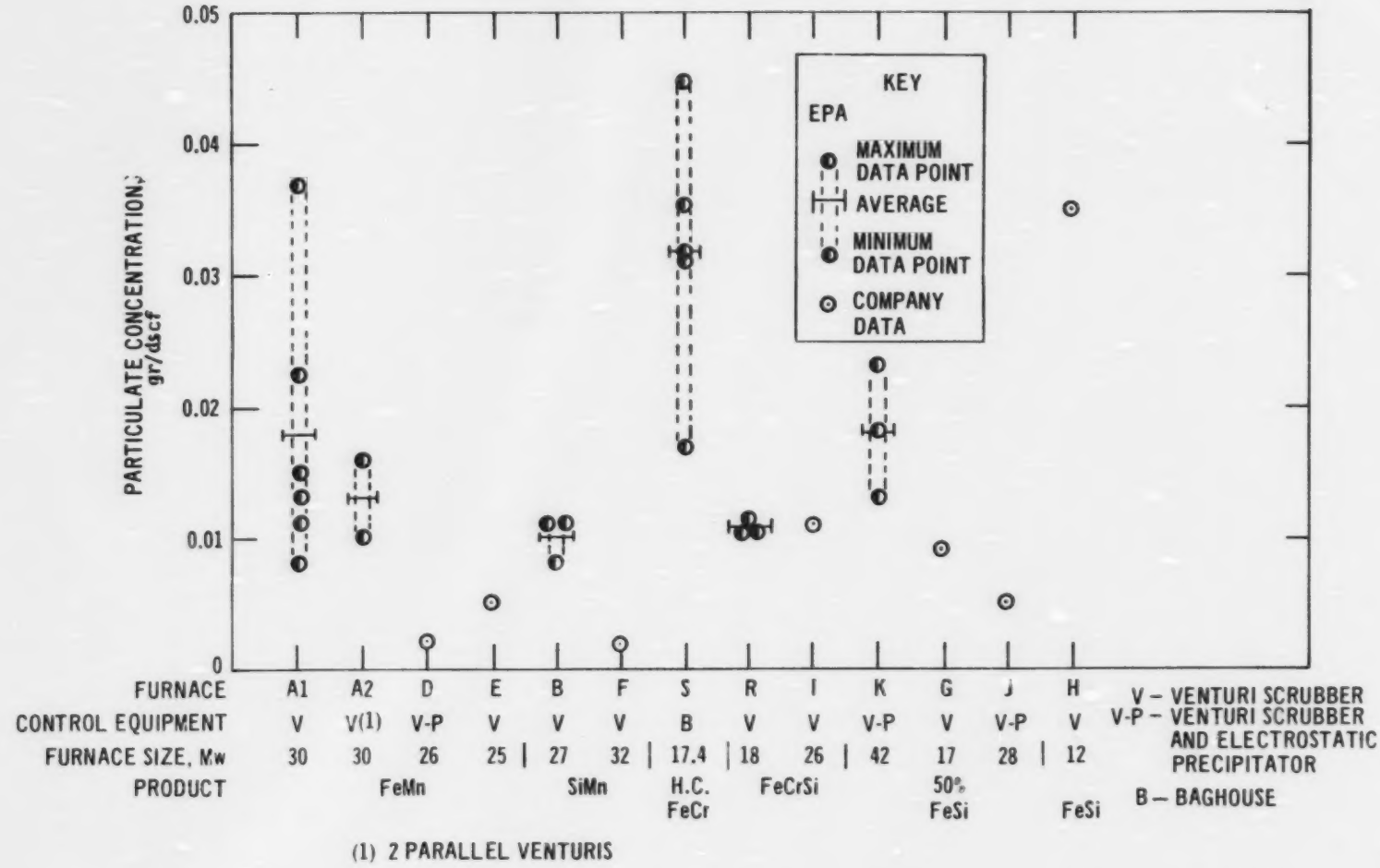

0.05
0.04
0.03
0.02
0.01
0
PARTICULATE CONCENTRATION, gr/dscf
KEY
EPA
MAXIMUM DATA POINT
AVERAGE
MINIMUM DATA POINT
COMPANY DATA
FURNACE A1 A2 D E B F S R I K G J H
CONTROL EQUIPMENT V V(1) V-P V V V V B V V V-P V V-P V
FURNACE SIZE, Mw 30 30 26 25 27 32 17.4 18 26 42 17 28 12
PRODUCT FeMn SiMn H.C. FeCr FeCrSi 50% FeSi FeSi
V – VENTURI SCRUBBER
V-P – VENTURI SCRUBBER AND ELECTROSTATIC PRECIPITATOR
B – BAGHOUSE
(1) 2 PARALLEL VENTURIS

Figure 1. Particulate concentrations in control system exhaust from sealed electric submerged-arc furnaces producing ferroalloys.

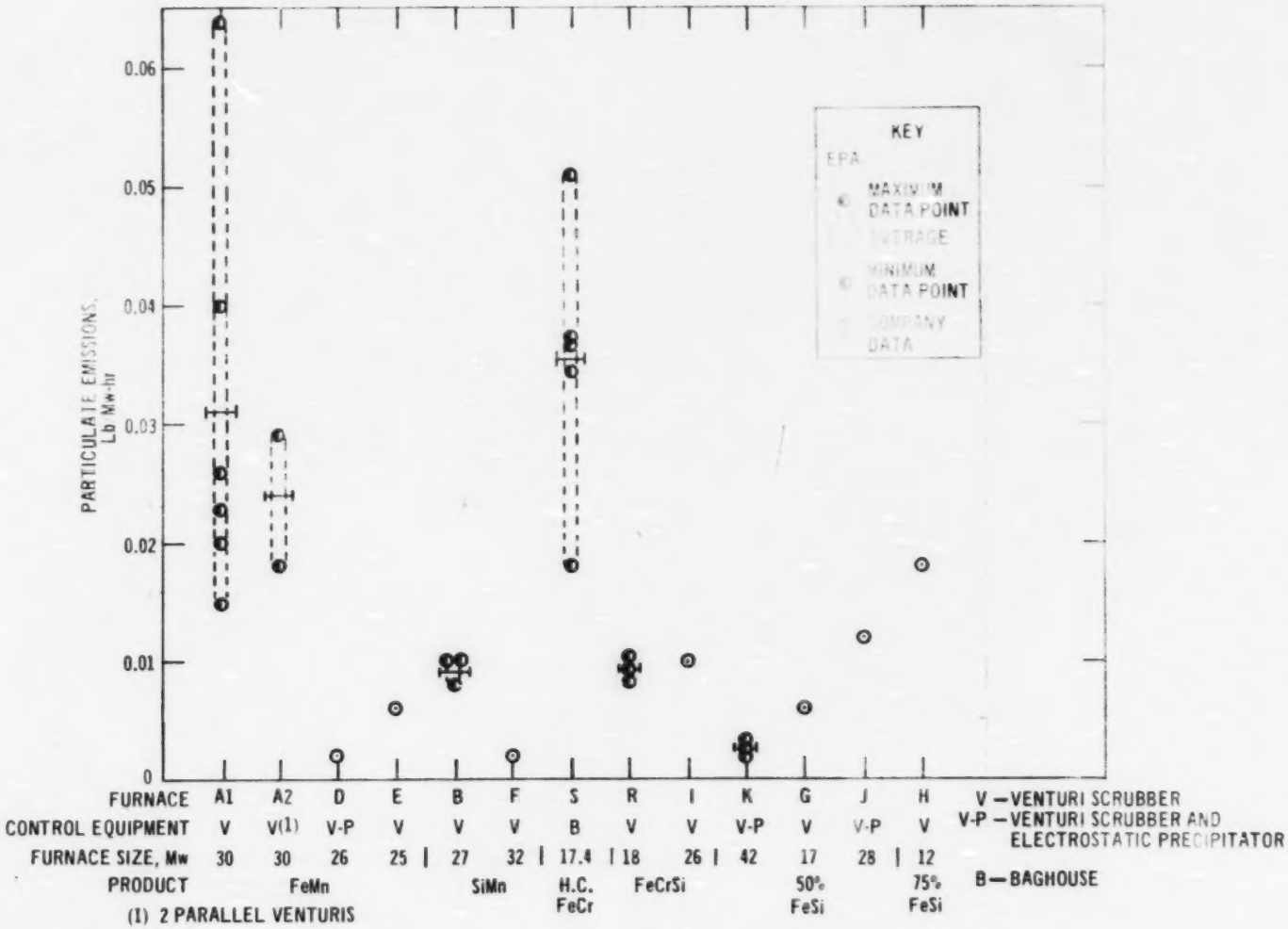

PARTICULATE EMISSIONS, Lb Mw-hr
0.06
0.05
0.04
0.03
0.02
0.01
0
KEY
EPA
MAXIMUM DATA POINT
AVERAGE
MINIMUM DATA POINT
COMPANY DATA
FURNACE A1 A2 D E B F S R I K G J H
CONTROL EQUIPMENT V V(1) V-P V V V V B V V V-P V V-P V
FURNACE SIZE, Mw 30 30 26 25 27 32 17.4 18 26 42 17 28 12
PRODUCT FeMn SiMn H.C. FeCr FeCrSi 50% FeSi 75% FeSi
(1) 2 PARALLEL VENTURIS
V — VENTURI SCRUBBER
V-P — VENTURI SCRUBBER AND ELECTROSTATIC PRECIPITATOR
B — BAGHOUSE

Figure 2. Particulate emissions (excluding tapping fumes and fugitive fumes) from sealed electric submerged-arc furnaces producing ferroalloys.

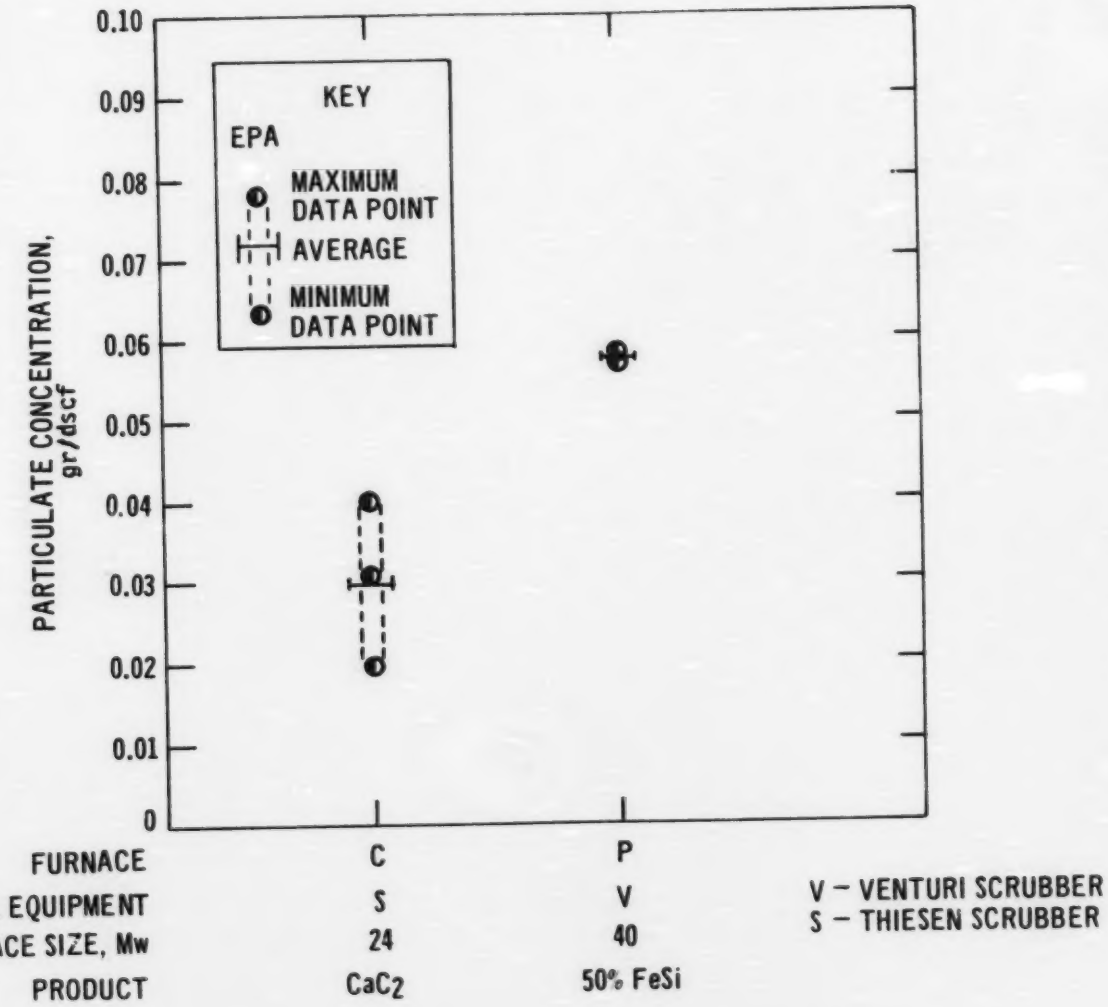
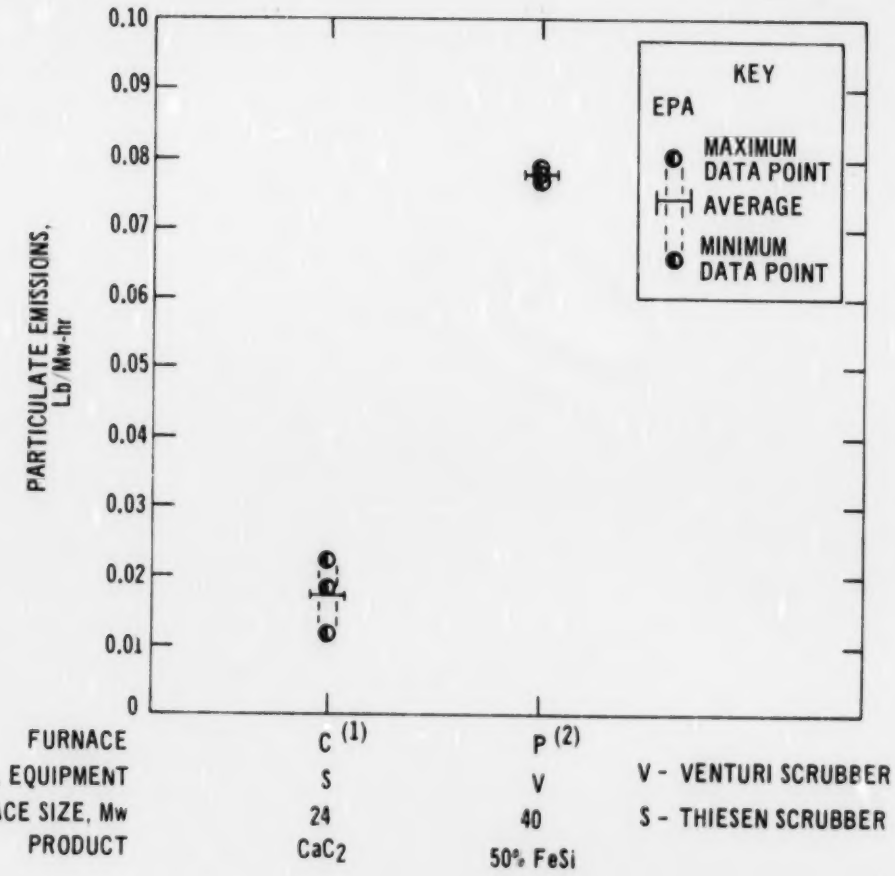


Figure 3. Particulate concentrations in control system exhaust from semi-enclosed electric submerged-arc furnaces producing ferroalloys.



(1) DOES NOT INCLUDE 48.2 lb/hr UNCONTROLLED FUGITIVE FUMES FROM AROUND THE ELECTRODES.

(2) DOES NOT INCLUDE 388 lb/hr UNCONTROLLED FUGITIVE FUMES FROM AROUND THE ELECTRODES.

Figure 4. Particulate emissions (excluding tapping fumes and fugitive fumes) from semi-enclosed electric submerged-arc furnaces producing ferroalloys.

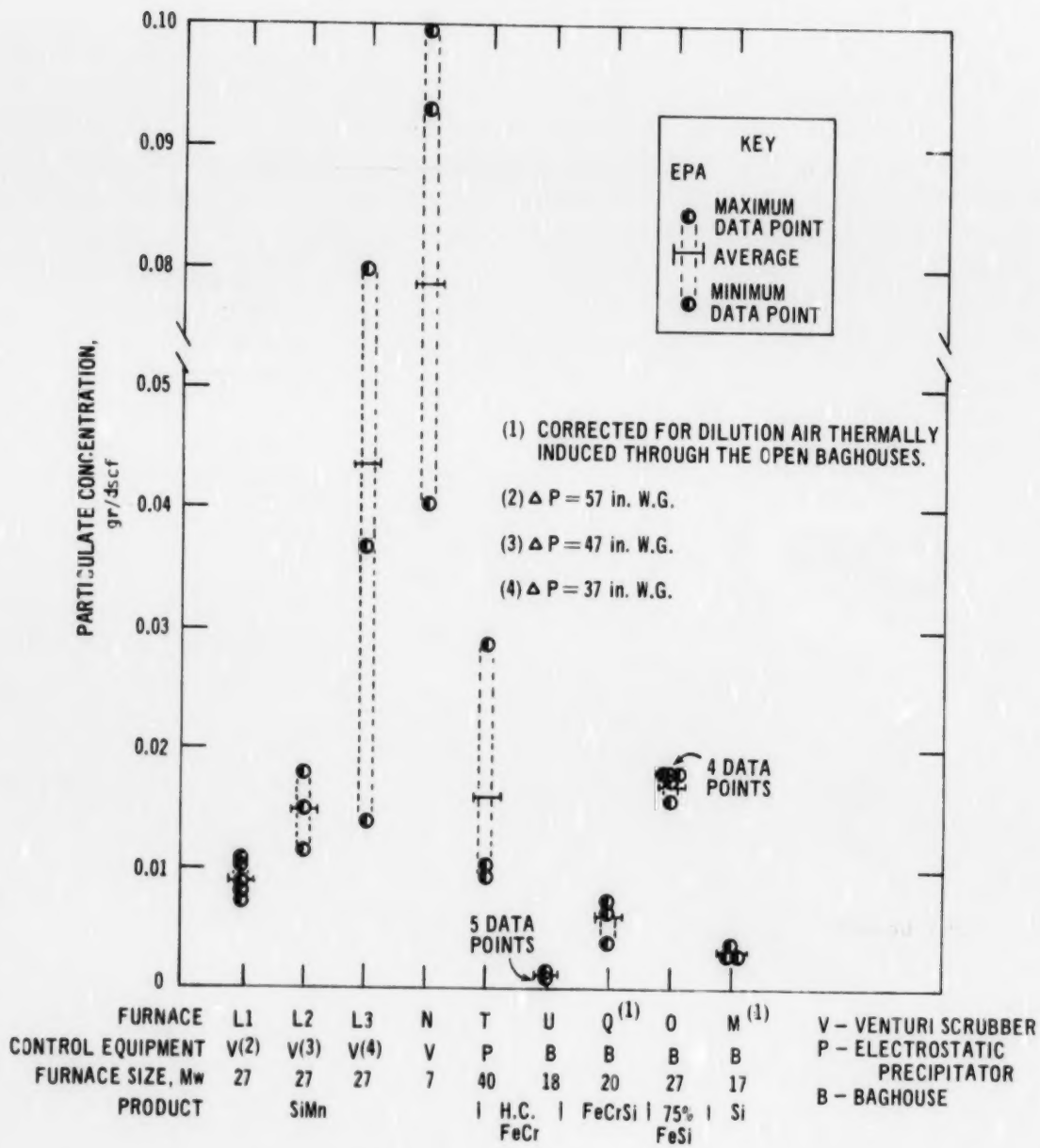

0.10
0.09
0.08
0.05
0.04
0.03
0.02
0.01
0
PARTICULATE CONCENTRATION, gr/dscf
KEY
EPA
MAXIMUM DATA POINT
AVERAGE
MINIMUM DATA POINT
(1) CORRECTED FOR DILUTION AIR THERMALLY INDUCED THROUGH THE OPEN BAGHOUSES.
(2) Δ P = 57 in. W.G.
(3) Δ P = 47 in. W.G.
(4) Δ P = 37 in. W.G.
4 DATA POINTS
5 DATA POINTS
FURNACE L1 L2 L3 N T U Q(1) O M(1)
CONTROL EQUIPMENT V(2) V(3) V(4) V P B B B B
FURNACE SIZE, Mw 27 27 27 7 40 18 20 27 17
PRODUCT SiMn H.C. FeCr FeCrSi 75% FeSi Si
V – VENTURI SCRUBBER
P – ELECTROSTATIC PRECIPITATOR
B – BAGHOUSE

Figure 5. Particulate concentrations in control system exhaust from open electric submerged-arc furnaces producing ferroalloys.

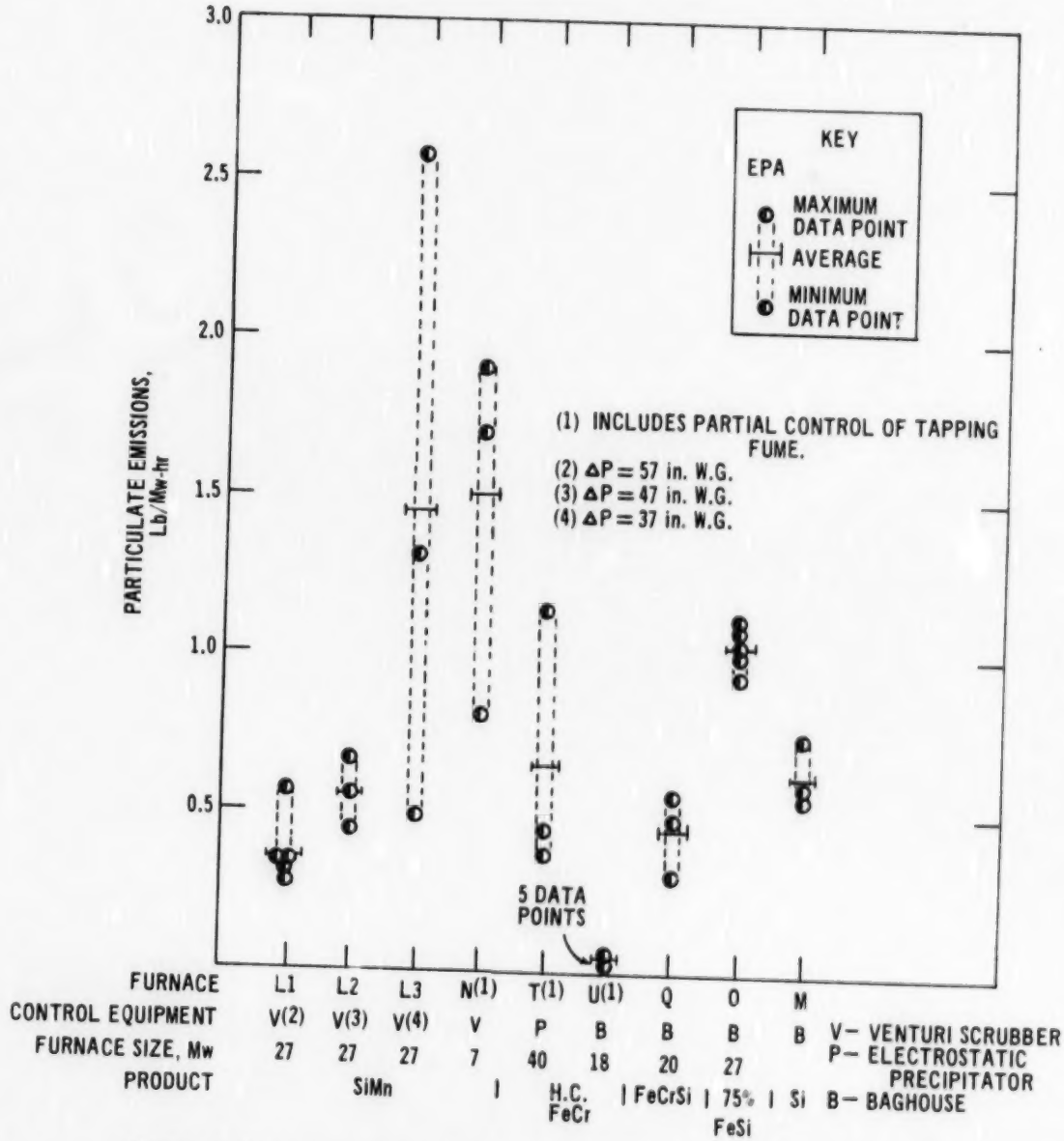

3.0
2.5
2.0
1.5
1.0
0.5
PARTICULATE EMISSIONS, Lb/Mw-hr
KEY
EPA
MAXIMUM DATA POINT
AVERAGE
MINIMUM DATA POINT
(1) INCLUDES PARTIAL CONTROL OF TAPPING FUME.
(2) ΔP = 57 in. W.G.
(3) ΔP = 47 in. W.G.
(4) ΔP = 37 in. W.G.
5 DATA POINTS
FURNACE L1 L2 L3 N(1) T(1) U(1) Q O M
CONTROL EQUIPMENT V(2) V(3) V(4) V P B B B B
FURNACE SIZE, Mw 27 27 27 7 40 18 20 27
PRODUCT SiMn | H.C. FeCr | FeCrSi | 75% FeSi | Si
V– VENTURI SCRUBBER
P– ELECTROSTATIC PRECIPITATOR
B– BAGHOUSE

Figure 6. Particulate emissions from open electric submerged-arc furnaces producing ferroalloys.

Table 1

FACILITY A1
Summary of Results

Run Number	1	2	3	4	5	6	Average
Date	8/16/72	8/16/72	8/17/72	8/17/72	8/18/72	8/18/72	--
Test Time-minutes	288	288	288	288	288	324	294
Average Power Input-megawatts	26	27	27	26	26	27	26
Stack Effluent							
Flow rate - DSCFM	5121	5463	5377	5394	5121	5453	5322
Temperature - ^{o}F	85	85	85	85	79.3	81.4	83.4
Water vapor - Vol. %	2.36	2.90	3.13	3.04	3.03	3.12	2.93
CO_2 - Vol. % dry	42.9	42.0	39.6	41.1	42.6	40.5	41.4
O_2 - Vol. % dry	0.29	0.6	0.6	0.6	0.8	0.5	0.6
CO - Vol. % dry	56.2	57.4	59.8	58.3	56.6	59.0	57.9
N_2 and other gases - Vol. % dry	--	--	--	--	--	--	--
Visible emissions at control system discharge - % opacity	0-<10	0-<10	0	0	0	0	<10
Particulate Emissions							
Probe and filter catch							
gr/DSCF	0.023	0.037	0.015	0.011	0.013	0.008	0.018
gr/ACF	0.023	0.036	0.008	0.011	0.013	0.008	0.016
lb/hr	1.03	1.73	0.70	0.51	0.59	0.40	0.83
lb/Mw-hr	0.040	0.064	0.026	0.020	0.023	0.015	0.031
Total catch							
gr/DSCF	0.025	0.039	0.017	0.012	0.015	0.010	0.020
gr/ACF	0.025	0.038	0.009	0.012	0.014	0.009	0.018
lb/hr	1.11	1.83	0.76	0.57	0.65	0.46	0.90
lb/Mw-hr	0.042	0.068	0.028	0.021	0.025	0.017	0.034

Reference 1.

Table 2

FACILITY A2
Summary of Results

Run Number	1	2	Average
Date	8/20/72	8/21/72	--
Test Time-minutes	327	294	310
Average Power Input-megawatts	27	27	27
Stack Effluent			
Flow rate - DSCFM	5653	5464	5559
Temperature - ^{o}F	87	83	85
Water vapor - Vol. %	2.30	2.22	2.26
CO_2 - Vol. % dry	38.4	38.2	38.3
O_2 - Vol. % dry	1.1	1.0	1.0
CO - Vol. % dry	60.6	60.8	60.7
N_2 and other gases - Vol. % dry	--	--	--
Visible emissions at control system discharge - % opacity	0	0	0
Particulate Emissions			
Probe and filter catch			
gr/DSCF	0.022	0.010(1)	0.016
gr/ACF	0.016(1)	0.010	0.013(1)
lb/hr	0.79	0.49	0.64
lb/Mw-hr	0.029	0.018	0.024
Total catch			
gr/DSCF	0.017(1)	0.011(1)	0.014(1)
gr/ACF	0.017	0.011	0.014
lb/hr	0.84	0.51	0.68
lb/Mw-hr	0.031	0.019	0.025

(1) Two stacks sampled simultaneously. These numbers are weighted to correct for unequal flows in each system.

Reference 1.

Table 3

FACILITY B
Summary of Results

Run Number	1	2	3	Average
Date	8/23/72	8/23/72	8/24/72	--
Test Time-minutes	320	320	320	320
Average Power Input-megawatts	23	22.5	23	23
Stack Effluent				
Flow rate - DSCFM	2339	2488	2425	2417
Temperature - ^{o}F	107.2	117.8	108.1	111.0
Water vapor - Vol. %	2.62	2.65	2.68	2.65
CO_2 - Vol. % dry	13.4	13.2	13.3	13.3
O_2 - Vol. % dry	0.4	0.4	0.9	0.6
CO - Vol. % dry	86.2	86.4	85.8	86.1
N_2 and other gases - Vol. % dry	--	--	--	--
Visible emissions at control system discharge - % opacity	0	0	0	0
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.011	0.008	0.011	0.010
gr/ACF	0.010	0.007	0.011	0.009
lb/hr	0.23	0.17	0.23	0.21
lb/Mw-hr	0.010	0.008	0.010	0.009
Total catch				
gr/DSCF	0.012	0.009	0.012	0.011
gr/ACF	0.012	0.008	0.011	0.010
lb/hr	0.25	0.19	0.26	0.23
lb/Mw-hr	0.011	0.008	0.011	0.010

Reference 1.

Table 4

FACILITY C
Summary of Results

Run Number	1	2	3	Average
Date	2/23/72	2/24/72	2/24/72	--
Test Time-minutes	60	60	60	60
Average Power Input-megawatts	24.0	23.8	23.5	23.8
Stack Effluent				
Flow rate - DSCFM	1585	1585	1585	1585
Temperature - ^{o}F	100	100	100	100
Water vapor - Vol. %	1.83	1.28	0.98	1.36
CO_2 - Vol. % dry	--	--	--	1.5
O_2 - Vol. % dry	--	--	--	6.0
CO - Vol. % dry	--	--	--	65(1)
N_2 and other gases - Vol % dry	--	--	--	27.5(1)
Visible emissions at control system discharge % opacity	0	0	0	0
Particulate Emissions(2)				
Probe and filter catch				
gr/DSCF	0.040	0.020	0.031	0.030
gr/ACF	0.037	0.019	0.029	0.028
lb/hr	0.533	0.266	0.413	0.404
lb/Mw-hr	0.022	0.011	0.018	0.017
Total catch				
gr/DSCF	0.0425	0.0311	0.0342	0.0359
gr/ACF	0.0449	0.0328	0.0361	0.0379
lb/hr	0.577	0.423	0.464	0.488
lb/Mw-hr	0.024	0.018	0.020	0.021

(1) Estimated. Carbon monoxide concentrations were higher than could be measured using the Orsat analyzer.

(2) Uncontrolled emissions at the electrode averaged 48.2 lb/hr.

Reference 2.

Table 5

FACILITY D
Summary of Results

Run Number	1
Date	--
Test Time-minutes	--
Average Power Input-megawatts	26
Stack Effluent	
Flow rate - DSCFM	3500
Temperature - ^{o}F	--
Water vapor - Vol. %	--
CO_2 - Vol. % dry	50
O_2 - Vol. % dry	--
CO - Vol. % dry	40-44
N_2 and other gases - Vol. % dry(1)	6-10
Visible emissions at control system discharge - % opacity	0
Particulate Emissions	
Probe and filter catch	
gr/DSCF	0.002
gr/ACF	--
lb/hr	0.055
lb/Mw-hr	0.002
Total catch	
gr/DSCF	--
gr/ACF	--
lb/hr	--
lb/Mw-hr	--

(1) Hydrogen content of the gas is 3 to 4 percent.

Reference 3.

Table 6

FACILITY E
Summary of Results

Run Number	1
Date	--
Test Time-minutes	--
Average Power Input-megawatts	25
Stack Effluent	
Flow rate - DSCFM	3500
Temperature - ^{o}F	--
Water vapor - Vol. %	--
CO_2 - Vol. % dry	--
O_2 - Vol. % dry	--
CO - Vol. % dry	--
N_2 and other gases - Vol. % dry	--
Visible emissions at control system discharge - % opacity	0
Particulate Emissions	
Probe and filter catch	
gr/DSCF	0.005
gr/ACF	--
lb/hr	0.150
lb/Mw-hr	0.006
Total catch	
gr/DSCF	--
gr/ACF	--
lb/hr	--
lb/Mw-hr	--

Reference 3.

Table 7

FACILITY F
Summary of Results

Run Number	1
Date	--
Test Time-minutes	--
Average Power Input-megawatts	29
Stack Effluent	
Flow rate - DSCFM	2900
Temperature - ^{o}F	--
Water vapor - Vol. %	--
CO_2 - Vol. % dry	20
O_2 - Vol. % dry	1.0
CO - Vol. % dry	75
N_2 and other gases - Vol. % dry	4
Visible emissions at control system discharge - % opacity	0
Particulate Emissions	
Probe and filter catch	
gr/DSCF	0.002
gr/ACF	--
lb/hr	0.050
lb/Mw-hr	0.002
Total catch	
gr/DSCF	--
gr/ACF	--
lb/hr	--
lb/Mw-hr	--

Reference 3.

Table 8

FACILITY G
Summary of Results

Run Number	1
Date	--
Test Time-minutes	--
Average Power Input-megawatts	17
Stack Effluent	
Flow rate - DSCFM	1300
Temperature - ^{o}F	86
Water vapor - Vol. %	--
CO_2 - Vol. % dry	--
O_2 - Vol. % dry	--
CO - Vol. % dry	80-97
N_2 and other gases - Vol. % dry	--
Visible emissions at control system discharge - % opacity	--
Particulate Emissions	
Probe and filter catch	
gr/DSCF	0.009
gr/ACF	--
lb/hr	0.100
lb/Mw-hr	0.006
Total catch	
gr/DSCF	--
gr/ACF	--
lb/hr	--
lb/Mw-hr	--

Reference 4.

Table 9

FACILITY H
Summary of Results

Run Number	1
Date	--
Test Time-minutes	--
Average Power Input-megawatts	12
Stack Effluent	
Flow rate - DSCFM	1120
Temperature - ^{o}F	--
Water vapor - Vol. %	--
CO_2 - Vol. % dry	1.3
O_2 - Vol. % dry	1.0
CO - Vol. % dry	79.5
N_2 and other gases - Vol. % dry(1)	9.2
Visible emissions at control system discharge - % opacity	--
Particulate Emissions	
Probe and filter catch	
gr/DSCF	0.035
gr/ACF	--
lb/hr	0.336
lb/Mw-hr	0.028
Total catch	
gr/DSCF	--
gr/ACF	--
lb/hr	--
lb/Mw-hr	--

(1) Gas is 1.7 percent methane and hydrocarbons.

Reference 3.

Table 10

FACILITY I
Summary of Results

Run Number	1
Date	--
Test Time-minutes	--
Average Power Input-megawatts	26
Stack Effluent	
Flow rate - DSCFM	2900
Temperature - ^{o}F	--
Water vapor - Vol. %	--
CO_2 - Vol. % dry	3
O_2 - Vol. % dry	--
CO - Vol. % dry	85
N_2 and other gases - Vol. % dry (1)	--
Visible emissions at control system discharge - % opacity	--
Particulate Emissions	
Probe and filter catch	
gr/DSCF	0.011
gr/ACF	--
lb/hr	0.272
lb/Mw-hr	0.010
Total catch	
gr/DSCF	--
gr/ACF	--
lb/hr	--
lb/Mw-hr	--

(1) Gas is 8 percent hydrogen.

Reference 3.

Table 11

FACILITY J
Summary of Results

Run Number	1
Date	--
Test Time-minutes	--
Average Power Input-megawatts	25
Stack Effluent	
Flow rate - DSCFM	7000
Temperature - ^{o}F	--
Water vapor - Vol. %	--
CO_2 - Vol. % dry	13
O_2 - Vol. % dry	--
CO - Vol. % dry	73
N_2 and other gases - Vol. % dry (1)	--
Visible emissions at control system discharge - % opacity	0
Particulate Emissions	
Probe and filter catch	
gr/DSCF	0.005
gr/ACF	--
lb/hr	0.300
lb/Mw-hr	0.012
Total catch	
gr/DSCF	--
gr/ACF	--
lb/hr	--
lb/Mw-hr	--

(1) Gas is 6 percent hydrogen.

Reference 3.

Table 12

FACILITY K

Summary of Results

Run Number	1	2	3	Average
Date	10/18/73	10/19/73	10/20/73	--
Test Time-minutes	315	360	360	345
Average Power Input-megawatts	30.7	29.8	32.4	31.0
Stack Effluent				
Flow rate - DSCFM	5130	5084	5060	5091
Temperature - ^{o}F	173	146	151	157
Water vapor - Vol. %	24.3	23.0	17.3	21.5
CO_2 - Vol. % dry	7.0	7.2	8.5	7.6
O_2 - Vol. % dry	0.0	0.2	0.3	0.2
CO - Vol. % dry	93.0	92.6	91.2	92.3
N_2 and other gases - Vol. % dry	--	--	--	--
Visible emissions at control system discharge - % opacity	0	0	0	0
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.0018	0.0023	0.0013	0.0018
gr/ACF	0.0012	0.0016	0.0010	0.0013
lb/hr	0.08	0.10	0.06	0.08
lb/Mw-hr	0.0025	0.0034	0.0019	0.0026
Total catch				
gr/DSCF	0.111	0.094	0.111	0.105
gr/ACF	0.074	0.066	0.084	0.075
lb/hr	4.88	4.07	4.81	4.59
lb/Mw-hr	0.159	0.137	0.148	0.148

Reference 5.

Table 13
FACILITY L1[1][2]
Summary of Results

Run Number	1	2	3	4	5	Average
Date	7/27/71	7/29/71	7/30/71	7/31/71	7/31/71	--
Test Time-minutes	80	80	80	95	90	85
Average Power Input-megawatts	29	25	20	24	27.5	25.1
Stack Effluent						
Flow rate - DSCFM	113,000	112,200	122,100	116,900	110,200	114,860
Temperature - ^{o}F	140	140	118	139	140	135
Water vapor - Vol. %	18.5	15.4	12.9	15.8	17.2	16.0
CO_2 - Vol. % dry	2.1	3.4	1.9	2.8	3.3	2.7
O_2 - Vol. % dry	19.2	18.3	18.6	18.8	18.4	18.7
CO - Vol. % dry	--	--	--	--	--	--
N_2 and other gases - Vol. % dry	78.7	78.3	79.5	78.4	78.3	78.6
Visible emissions at control system discharge - % opacity	--	--	--	--	--	--
Particulate Emissions[3]						
Probe and filter catch						
gr/DSCF	0.0103	0.00710	0.0107	0.00813	0.00889	0.00902
gr/ACF	0.00728	0.00520	0.00839	0.00594	0.00684	0.00673
lb/hr	9.97	6.83	11.2	8.14	8.39	8.91
lb/Mw-hr	0.34	0.27	0.56	0.34	0.31	0.36
Total catch						
gr/DSCF	0.0166	0.0110	0.0122	0.00967	0.0105	0.0120
gr/ACF	0.0117	0.00805	0.00956	0.00706	0.00807	0.00889
lb/hr	16.1	10.5	12.8	9.68	9.91	11.8
lb/Mw-hr	0.56	0.42	0.64	0.40	0.36	0.48

(1) Sampling was performed along one axis only.

(2) Scrubber pressure drop of 57 inches W.G.

(3) Does not include uncontrolled tapping fumes which are 19 to 48 lb/hr during tapping.

Reference 6.

Table 14

FACILITY L2[1][2]

Summary of Results

Run Number	1	2	3	Average
Date	8/1/71	8/2/71	8/2/71	--
Test Time-minutes	90	90	90	90
Average Power Input-megawatts	27.5	27.0	27.5	27.3
Stack Effluent				
Flow rate - DSCFM	118,100	115,000	121,100	118,070
Temperature - ^{o}F	135	127	134	132
Water vapor - Vol. %	16.1	18.2	15.3	16.5
CO_2 - Vol. % dry	3.0	3.2	3.4	3.2
O_2 - Vol. % dry	18.6	18.6	18.5	18.6
CO - Vol. % dry	--	--	--	--
N_2 and other gases - Vol. % dry	78.4	78.2	78.1	78.2
Visible emissions at control system discharge - % opacity	--	--	--	--
Particulate Emissions[3]				
Probe and filter catch				
gr/DSCF	0.0150	0.0180	0.0114	0.0148
gr/ACF	0.0111	0.0132	0.00831	0.0109
lb/hr	15.2	17.7	11.8	14.9
lb/Mw-hr	0.55	0.66	0.43	0.55
Total catch				
gr/DSCF	0.0170	0.0197	0.0131	0.0166
gr/ACF	0.0126	0.0144	0.00955	0.0122
lb/hr	17.2	19.4	13.6	16.7
lb/Mw-hr	0.63	0.72	0.49	0.61

(1) Same as facility L1 except the scrubber pressure drop was only 47 inches w.g.

(2) Sampling was performed along one axis only.

(3) Does not include uncontrolled tapping fumes which are 19 to 48 lb/hr during tapping.

Reference 6.

Table 15
FACILITY L3(1)(2)
Summary of Results

Run Number	1	2	3	Average
Date	8/3/71	8/3/71	8/4/71	--
Test Time-minutes	90	90	90	90
Average Power Input-megawatts	28.0	27.0	27.5	27.5
Stack Effluent				
Flow rate - DSCFM	114,300	112,000	103,200	109,830
Temperature - ^{o}F	130	133	132	132
Water vapor - Vol. %	17.6	16.7	17.6	17.3
CO_2 - Vol. % dry	3.2	3.2	3.1	3.2
O_2 - Vol. % dry	18.8	18.6	18.7	18.7
CO - Vol. % dry	--	--	--	--
N_2 and other gases - Vol. % dry	78.0	78.2	78.2	78.1
Visible emissions at control system discharge - % opacity	--	--	--	--
Particulate Emissions(3)				
Probe and filter catch				
gr/DSCF	0.0138	0.0369	0.0798	0.0435
gr/ACF	0.0100	0.0270	0.0576	0.0315
lb/hr	13.5	35.4	70.6	39.8
lb/Mw-hr	0.48	1.31	2.57	1.45
Total catch				
gr/DSCF	0.0144	0.0445	0.0849	0.0479
gr/ACF	0.0104	0.0326	0.0613	0.0348
lb/hr	14.1	42.7	75.1	44.0
lb/Mw-hr	0.50	1.58	2.73	1.60

(1) Same as facilities L1 and L2 except the scrubber pressure drop was only 37 inches w.g.

(2) Sampling was performed along one axis only.

(3) Does not include uncontrolled tapping fumes which are 19 to 48 lb/hr during tapping.

Reference 6.

Table 16

FACILITY M

Summary of Results

Run Number	1	2	3	Average
Date	1/17/72	1/18/72	1/20/72	-
Test Time-minutes	367	360	292	340
Average Power Input - MegaWatts	17	17	17	17
Stack Effluent				
Flow rate - DSCFM(1)	581,150	631,550	619,550	610,750
Temperature - °F	180	220	200	200
Water vapor - Vol. %	0	0	0.37	0.12
CO_2 - Vol.% dry	-	-	0.2	-
O_2 - Vol.% dry	-	-	20.7	-
CO - Vol.% dry	-	-	-	-
N_2 and other gases - Vol. % dry	-	-	79.1	-
Visible emissions at control system discharge - % opacity	0	0	0	0
Particulate Emissions(2)				
Probe and filter catch				
gr/DSCF	0.0025	0.0018	0.0017	0.0020
gr/ACF	0.0021	0.0014	0.0016	0.0017
lb/hr	12.5	9.75	9.03	10.4
lb/Mw-hr	0.735	0.574	0.531	0.613
Total catch				
gr/DSCF	0.0032	0.0039	0.0046	0.0039
gr/ACF	0.0026	0.0030	0.0037	0.0031
lb/hr	16.3	21.1	24.4	20.6
lb/Mw-hr	0.959	1.24	1.44	1.21

(1) Total flow from all three baghouses including cooling air induced through open grates surrounding the tube sheets.

(2) Does not include uncontrolled tapping fume.

Reference 7.

Table 17

FACILITY N
Summary of Results

Run Number	1	2	3	Average
Date	2/1/72	2/2/72	2/2/72	--
Test Time-minutes	138	108	103	116
Average Power Input-megawatts	7.2	7.2	7.2	7.2
Stack Effluent				
Flow rate - DSCFM	16,880	15,500	15,500	15,960
Temperature - ^{o}F	137	131	131	133
Water vapor - Vol. %	10.3	15.5	15.5	13.8
CO_2 - Vol. % dry	4.3	4.0	4.0	4.1
O_2 - Vol. % dry	16.9	17.2	17.2	17.1
CO - Vol. % dry	--	--	--	--
N_2 and other gases - Vol. % dry	78.8	78.8	78.8	78.8
Visible emissions at control system discharge - % opacity	0	0	0	0
Particulate Emissions (1)				
Probe and filter catch				
gr/DSCF	0.0403	0.0932	0.102	0.0785
gr/ACF	0.0340	0.0701	0.0767	0.0603
lb/hr	5.83	12.38	13.55	10.59
lb/Mw-hr	0.81	1.7	1.9	1.5
Total catch				
gr/DSCF	0.0489	0.101	0.107	0.0856
gr/ACF	0.0386	0.0759	0.0804	0.0650
lb/hr	7.08	13.42	14.21	11.57
lb/Mw-hr	0.98	1.9	2.0	1.6

(1) Partial control of tapping fume exists. Results include the controlled tap fume. Estimated capture efficiency of the tapping hood is 20 percent.

Reference 8.

Table 18

FACILITY O
Summary of Results (1)

Run Number	1 (2)	2	3	4	5	Average
Date	10/11/73	10/11/73	10/12/73	10/12/73	10/12/73	--
Test Time-minutes	108	108	144	144	144	130
Average Power Input-megawatts	23.0	22.9	22.8	21.3	21.5	22.3
Stack Effluent						
Flow rate - DSCFM (3)	162713	164749	153126	147235	148710	157886
Temperature - ^{o}F (4)	359	367	388	389	393	379
Water vapor - Vol. %	1.7	2.2	1.9	2.0	1.9	1.9
CO_2 - Vol. % dry	1.6	1.6	1.7	1.7	1.7	1.7
O_2 - Vol. % dry	19.7	19.7	19.9	19.9	19.9	19.8
CO - Vol. % dry	0.0	0.0	0.0	0.0	0.0	0.0
N_2 and other gases - Vol. % dry	78.7	78.7	78.4	78.4	78.4	78.5
Visible emissions at control system discharge - % opacity	$\leq$ 15	$\leq$15	$\leq$15	$\leq$15	$\leq$ 15	$\leq$15
Particulate Emissions (5)						
Probe and filter catch						
gr/DSCF	0.01712	0.01724	0.01724	0.01570	0.01724	0.01691
gr/ACF	0.01098	0.01089	0.01065	0.00967	0.01058	0.01055
lb/hr	25.44	24.34	22.62	19.81	21.97	22.84
lb/Mw-hr	1.11	1.06	0.99	0.93	1.02	1.02
Total catch						
gr/DSCF	0.03090	0.02993	0.02469	0.02528	0.02374	0.02691
gr/ACF	0.01982	0.01891	0.01524	0.01557	0.01458	0.01682
lb/hr	43.09	42.26	32.40	31.90	30.26	35.98
lb/Mw-hr	1.87	1.85	1.42	1.50	1.41	1.61

(1) One stack of three on the baghouse was sampled. Gas flow rates were measured on the other two.

(2) Did not include a complete tap.

(3) Total from baghouse.

(4) Of stack sampled.

(5) Does not include uncontrolled tap fumes. Mass emissions were calculated as the product of the concentration measured on one stack and the total gas flow.

Reference 9.

Table 19
FACILITY O
SUMMARY OF VISIBLE EMISSIONS (1)

Date: 10/11/73
Type of Plant: Submerged arc 75% ferrosilicon furnace
Type of Discharge: 3 stacks
Location of Discharge: Baghouse
Height of Point of Discharge: ∿ 100 ft
Description of Background: Sky
Distance from Observer to Discharge Point: ∿ 200 ft
Height of Observation Point: Ground level (
Direction of Observer from Discharge Point: Southwest

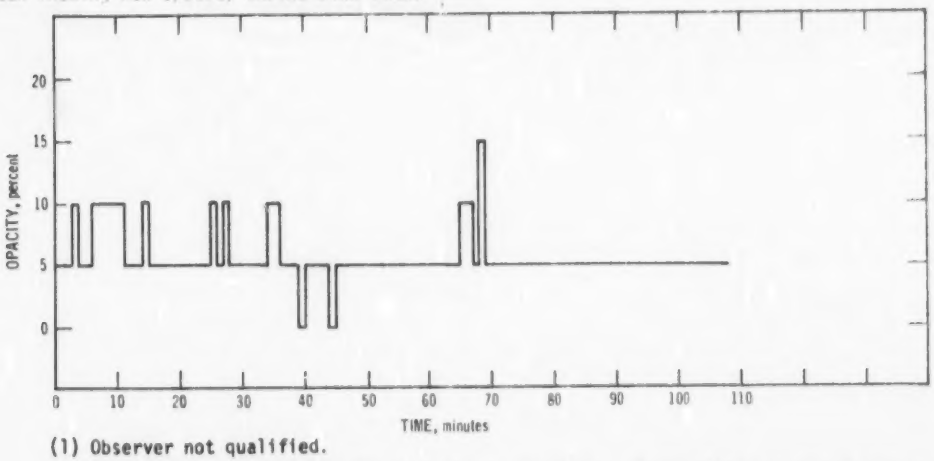
Description of Sky: Clear with occasional clouds.

Wind Direction: From Southeast
Color of Plume: White
Interference of Steam Plume: None
Duration of Observation: 1 hr. 48 min.
Wind Velocity: 0 to 10 mi/hr
Detached Plume: No

Summary of Data: (2)

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity		Opacity, Percent	Total Time Equal to or Greater Than Given Opacity	
	Min.	Sec.		Min.	Sec.
5	106	0	55	-	-
10	14	0	60	-	-
15	1	0	65	-	-
20	0	0	70	-	-
25	-	-	75	-	-
30	-	-	80	-	-
35	-	-	85	-	-
40	-	-	90	-	-
45	-	-	95	-	-
50	-	-	100	-	-

Sketch Showing How Opacity Varied With Time:



(1) Observer not qualified.

(2) The highest reading from the 3 stacks is reported. Observations were made concurrently with Run Number 2, Table 18.

Reference 9.

Table 20

FACILITY P
Summary of Results (1)

Run Number	1	2	Average
Date	7/19/72	7/19/72	--
Test Time-minutes	60	60	60
Average Power Input-megawatts	46.	47.	46.5
Stack Effluent			
Flow rate - DSCFM	7307 (2)	7258 (2)	7283
Temperature - ^{o}F	152 (2)	149 (2)	151
Water vapor - Vol. %	6.38 (2)	6.69 (2)	6.54
CO_2 - Vol. % dry	2.00	2.80	2.40
O_2 - Vol. % dry	1.20	2.00	1.60
CO - Vol. % dry	96.8	95.2	96.0
N_2 and other gases - Vol. % dry	--	--	--
Visible emissions at control system discharge - % opacity	--	--	--
Particulate Emissions			
Probe and filter catch			
gr/DSCF	0.0573 (2)	0.0580 (2)	0.0577
gr/ACF	0.0468 (2)	0.0475 (2)	0.472
lb/hr	3.60 (2)	3.60 (2)	3.60
lb/Mw-hr	0.0783 (2)	0.0766 (2)	0.0775
Total catch			
gr/DSCF	0.0679 (2)	0.0695 (2)	0.0687
gr/ACF	0.0555 (2)	0.0568 (2)	0.0562
lb/hr	4.25 (2)	4.35 (2)	4.30
lb/Mw-hr	0.0924 (2)	0.0926 (2)	0.0925

(1) Exluding tapping emissions and fugitive emissions from the electrode holes which averaged 388 lb/hr (probe and filter catch) during a previous test of this facility.

(2) Two test trains, one on each traverse, were used. Values are averages of measurements obtained by each test train.

References 2 and 10.

Table 21

FACILITY Q[1]

Summary of Results

Run Number	1	2	3	Average
Date	8/31/71	9/1/71	9/1/71	--
Test Time-minutes	120	120	180	140
Average Power Input-megawatts	20	20	20	20
Stack Effluent				
Flow rate - DSCFM[2]	383,000	383,000	383,000	383,000
Temperature - ^{o}F	165	175	176	172
Water vapor - Vol. %[3]	1.03	0.527	0.403	0.653
CO_2 - Vol. % dry	0.5	0.5	0.5	0.5
O_2 - Vol. % dry	20.6	20.6	20.6	20.6
CO - Vol. % dry	--	--	--	--
N_2 and other gases - Vol. % dry	78.9	78.9	78.9	78.9
Visible emissions at control system discharge - % opacity[4]		--	--	0
Particulate Emissions				
Probe and filter catch				
gr/DSCF[3]	0.0033	0.0029	0.0018	0.0027
gr/ACF[3]	0.0028	0.0024	0.0014	0.0022
lb/hr[5]	11	9.4	5.8	8.7
lb/Mw-hr	0.55	0.47	0.29	0.44
Total catch				
gr/DSCF[3]	0.0115	0.0099	0.0055	0.0090
gr/ACF[3]	0.0095	0.0082	0.0045	0.0074
lb/hr[5]	37.9	32.5	18.1	29.5
lb/Mw-hr	1.9	1.6	0.91	1.5

(1) Testing was not isokinetic and was conducted simultaneously by three trains each at a single point in the baghouse monitor. Results do not include uncontrolled tap fumes.

(2) Obtained as sum of inlet air flow rate and induced baghouse cooling air measured with a vane anemometer.

(3) Average of measurements of three trains at three points in the baghouse monitor.

(4) Visible emission readings were obtained on February 20, 1974 for 4 hours.

(5) Based on average grain loading and total air flow at the baghouse exhaust.

Reference 11.

Table 22
FACILITY Q
SUMMARY OF VISIBLE EMISSIONS(1)

Date: 2/23/74

Type of Plant: Submerged Arc Ferrochrome Silicon Furnace

Type of Discharge: Monitor

Distance from Observer to Discharge Point: ∿ 300 ft

Location of Discharge: Top of baghouse

Height of Observation Point: Ground level

Height of Point of Discharge: ∿ 60 ft

Direction of Observer from Discharge Point: East

Description of Background: Sky

Description of Sky: Overcast with some periods of clear sky especially near the end of the observations.

Wind Direction: From West and Northwest

Wind Velocity: ∿ 10 mi/hr

Color of Plume: -

Detached Plume: No

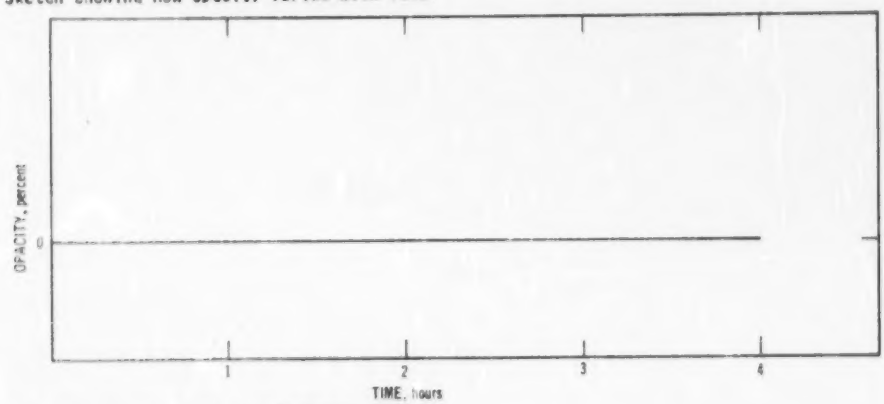
Interference of Steam Plume: None

Duration of Observation: 4 hours

Summary of Data:

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity		Opacity, Percent	Total Time Equal to or Greater Than Given Opacity	
	Min.	Sec.		Min.	Sec.
5	Emissions were 0 percent opacity throughout the observation period.		55		
10			60		
15			65		
20			70		
25			75		
30			80		
35			85		
40			90		
45			95		
50			100		

Sketch Showing How Opacity Varied With Time:



(1) Two observers made simultaneous readings.

References 12 and 13.

Table 23

FACILITY R

Summary of Results

Run Number	1	2	3	Average
Date	10/4/73	10/4/73	10/5/73	--
Test Time-minutes	240	240	240	240
Average Power Input-megawatts	18.1	18.2	19.5	18.6
Stack Effluent				
Flow rate - DSCFM	1675	1925	2028	1876
Temperature - ^{o}F	78	102	92	91
Water vapor - Vol. %	5.1	5.5	4.6	5.1
CO_2 - Vol. % dry	0.9	0.9	3.1	1.6
O_2 - Vol. % dry	0.2	0.2	0.6	0.3
CO - Vol. % dry	98.9	98.9	96.3	98.0
N_2 and other gases - Vol. % dry	--	--	--	--
Visible emissions at control system discharge - % opacity	0	0	0	0
Particulate Emissions				
Probe and filter catch				
gr/DSCF	0.01041	0.01132	0.01051	0.01075
gr/ACF	0.00977	0.01013	0.00966	0.00985
lb/hr	0.15	0.19	0.18	0.17
lb/Mw-hr	0.00826	0.01026	0.00937	0.00930
Total catch				
gr/DSCF	0.01063	0.01248	0.01124	0.01145
gr/ACF	0.00998	0.01118	0.01034	0.01050
lb/hr	0.15	0.21	0.20	0.19
lb/Mw-hr	0.00843	0.01131	0.01002	0.00992

Reference 14.

Table 24

FACILITY R

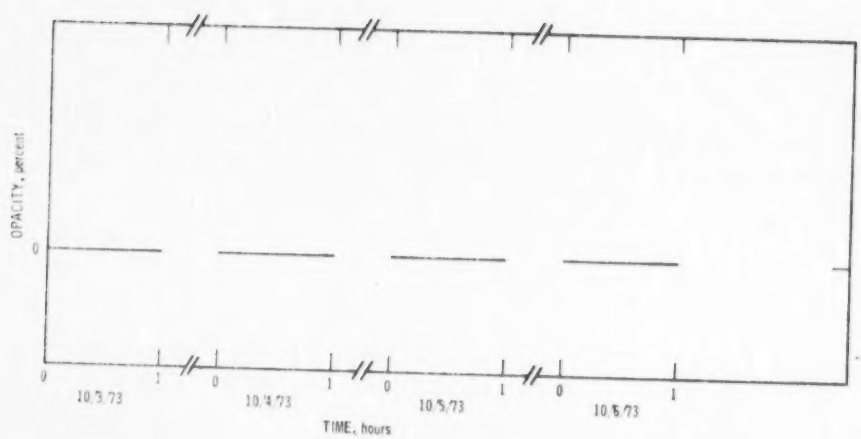
SUMMARY OF VISIBLE EMISSIONS

Date:	10/3/73 through 10/6/73		
Type of Plant:	Sealed, Submerged Arc Ferrochrome Silicon Furnace		
Type of Discharge:	Flare	Distance from Observer to Discharge Point:	30 to 80 ft.
Location of Discharge:	Stack, Exhaust from Scrubber	Height of Observation Point:	~125 ft.
Height of Point of Discharge:	~125 ft.	Direction of Observer from Discharge Point:	--
Description of Background:	Sky		
Description of Sky:	Overcast except on 10/6/73 when it was clear		
Wind Direction:	Generally from North	Wind Velocity:	4.5 to 13 mi/hr
Color of Plume:	-	Detached Plume:	No
Interference of Steam Plume:	None		
Duration of Observation:	1 hour on each day, 4 hours total.		

Summary of Data:

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity Min.	Sec.	Opacity, Percent	Total Time Equal to or Greater Than Given Opacity Min.	Sec.
5	Emissions were 0 percent opacity throughout the observation periods.		55		
10			60		
15			65		
20			70		
25			75		
30			80		
35			85		
40			90		
45			95		
50			100		

Sketch Showing How Opacity Varied with Time:



reference 14.

Table 25

FACILITY S

Summary of Results

Run Number	1	2	3	4	5	Average
Date	10/4/73	10/5/73	10/8/73	10/8/73	10/9/73	--
Test Time-minutes	240	240	240	240	240	240
Average Power Input-megawatts	17.2	16.8	18.0	18.4	19.5	18.0
Stack Effluent						
Flow rate - DSCFM	2169	2231	2037	2532	2689	2332
Temperature - ^{o}F	92	275	114	123	119	145
Water vapor - Vol. %	5.2	0.0	10.7	10.1	6.8	6.6
CO_2 - Vol. % dry	1.5	2.4	2.0	2.8	3.3	2.4
O_2 - Vol. % dry	0.5	0.2	0.5	0.3	0.3	0.4
CO - Vol. % dry	98.0	97.4	97.5	96.9	96.4	97.2
N_2 and other gases - Vol. % dry	--	--	--	--	--	--
Visible emissions at control system discharge - % opacity	0	0	0	0	0	0
Particulate Emissions						
Probe and filter catch						
gr/DSCF	0.0166	0.0448	0.0354	0.0311	0.0316	0.0319
gr/ACF	0.0153	0.0325	0.0293	0.0256	0.0274	0.0260
lb/hr	0.31	0.86	0.62	0.68	0.73	0.64
lb/Mw-hr	0.0180	0.0510	0.0344	0.0367	0.0374	0.0355
Total catch						
gr/DSCF	0.0189	0.0514	0.0383	0.0334	0.0365	0.0357
gr/ACF	0.0173	0.0373	0.0317	0.0274	0.0315	0.0290
lb/hr	0.35	0.98	0.67	0.73	0.84	0.71
lb/Mw-hr	0.0204	0.0585	0.0371	0.0394	0.0431	0.0397

Reference 15.

Table 26

FACILITY S

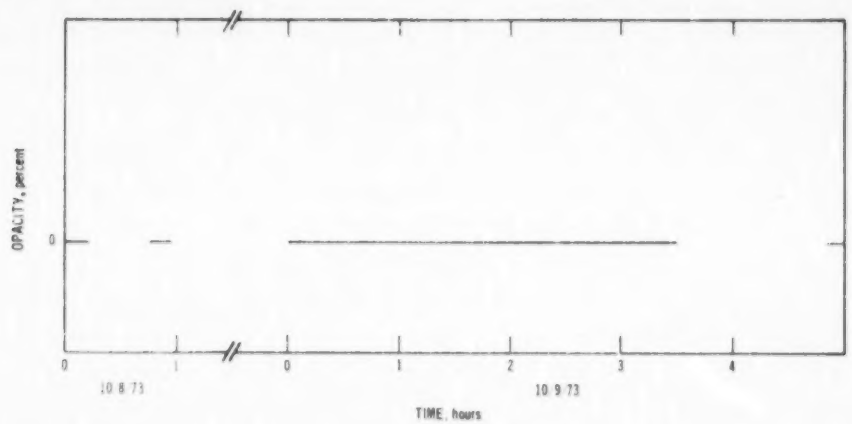
SUMMARY OF VISIBLE EMISSIONS[1]

Date:	10/8/73 - 10/9/73		
Type of Plant:	Sealed, Submerged Arc High Carbon Ferrochrome Furnace		
Type of Discharge:	Flare	Distance form Observer to Discharge Point:	150 ft & 90 ft. (2 locations)
Location of Discharge:	Stack, Exhaust From Baghouse	Height of Observation Point:	Ground level
Height of Point of Discharge:	100 ft.	Direction of Observer from Discharge Point:	Northwest
Description of Background:	Sky		
Description of Sky:	10/8/73 - Overcast 10/9/73 - Clear		
Wind Direction:	Varied	Wind Velocity:	0 to 2 mi/hr
Color of Plume:	-	Detached Plume:	Visible emissions were read at the tip of the flame.
Interference of Steam Plume:	None		
Duration of Observation:	10/8/73 - 12:40 p.m. to 12:52 p.m. and 2:13 p.m. to 2:25 p.m. (24 minutes) 10/9/73 - 9:00 a.m. to 12:30 p.m. (3 hr. 30 min.)		

Summary of Data:[2]

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity Min.	Sec.	Opacity, Percent	Total Time Equal to or Greater Than Given Opacity Min.	Sec.
5	Emissions were 0 percent opacity throughout the observation periods.		55		
10			60		
15			65		
20			70		
25			75		
30			80		
35			85		
40			90		
45			95		
50			100		

Sketch Showing How Opacity Varied With Time:



(1) Observer not qualified.

(2) Readings were made concurrently with quantitative emission measurements. See Table 25. Reference 15.

Table 27

FACILITY T
Summary of Results

Run Number	1	2	3	Average
Date	9/21/71	9/22/71	9/23/71	
Test Time-minutes	360	360	360	360
Average Power Input-megawatts	32.2	33.4	32.5	32.7
Stack Effluent				
Flow rate - DSCFM	148,400	159,000	161,000	156,130
Temperature - ^{o}F	219	217	215	217
Water vapor - Vol. %	8.4	9.5	8.9	8.9
CO_2 - Vol. % dry	1.6	2.4	2.2	2.1
O_2 - Vol. % dry	20.2	19.8	19.4	19.8
CO - Vol. % dry				
N_2 and other gases - Vol. % dry	78.2	77.8	78.4	78.1
Visible emissions at control system discharge - % opacity	<5(2)	≤20	≤20	≤20
Particulate Emissions(1)				
Probe and filter catch				
gr/DSCF	0.0286	0.00916	0.01032	0.0160
gr/ACF	0.0207	0.00656	0.00748	0.0116
lb/hr	36.3	12.5	14.2	21.0
lb/Mw-hr	1.13	0.37	0.44	0.65
Total catch				
gr/DSCF	0.0310	0.0115	0.01247	0.0183
gr/ACF	0.0224	0.00824	0.00904	0.0132
lb/hr	39.4	15.7	17.2	24.1
lb/Mw-hr	1.22	0.47	0.53	0.74

(1) Partial collection of tap fumes exists. Collected tap fume is added to the furnace gas and is controlled by the same control device as the furnace gas.

(2) Based on one five minute period of observation during run 1.

Reference 16

Table 28

FACILITY U
Summary of Results (1)

Run Number	1	2	3	4	5	Average
Date	10/10/73	10/10/73	10/13/73	10/14/73	10/14/73	--
Test Time-minutes	300	300	300	300	300	300
Average Power Input-megawatts	14.9	15.3	15.5	15.1	14.4	15.0
Stack Effluent						
Flow rate - DSCFM (2)	62540	60630	57700	55120	58160	58830
Temperature - ^{o}F (3)	489	496	480	489	450	481
Water vapor - Vol. %	2.3	2.2	3.3	2.9	2.4	2.6
CO_2 - Vol. % dry	3.0	2.9	2.6	2.6	3.5	2.9
O_2 - Vol. % dry	19.9	19.8	20.1	20.1	19.8	19.9
CO - Vol. % dry	--	--	--	--	--	--
N_2 and other gases - Vol. % dry	77.1	77.3	77.3	77.3	76.7	77.1
Visible emissions at control system discharge - % opacity	0	0	0	0	0	0
Particulate Emissions (4)						
Probe and filter catch						
gr/DSCF	0.00126	0.00113	0.00066	0.00073	0.00138	0.00103
gr/ACF	0.00069	0.00061	0.00036	0.00039	0.00078	0.00057
lb/hr	0.675	0.585	0.328	0.343	0.686	0.523
lb/Mw-hr	0.0453	0.0382	0.0212	0.0227	0.0476	0.0350
Total catch						
gr/DSCF	0.00552	0.00931	0.00517	0.00552	0.00600	0.00630
gr/ACF	0.00303	0.00509	0.00279	0.00297	0.00338	0.00345
lb/hr	2.73	4.84	2.55	2.60	2.99	3.14
lb/Mw-hr	0.183	0.316	0.165	0.172	0.208	0.209

(1) One stack of three on the baghouse was sampled. Gas flow rates were measured on the other two.
(2) Total from baghouse.
(3) Of stack sampled.
(4) Includes controlled tap fumes which are captured by the tapping hood. Mass emissions were calculated as the product of the concentration measured on one stack and the total gas flow.

Reference 17.

Table 29

FACILITY U

SUMMARY OF VISIBLE EMISSIONS

Date:	10/10/73 and 10/14/73		
Type of Plant:	Submerged Arc High Carbon Ferrochrome Furnace		
Type of Discharge:	3 stacks	Distance from Observer to Discharge Point:	20 to 30 ft.
Location of Discharge:	Baghouse	Height of Observation Point:	90 to 100 ft.
Height of Point of Discharge:	100 ft.	Direction of Observer from Discharge Point:	Varied
Description of Background:	Observations were made against the dark background of distant mountains and against the sky at various times.		
Description of Sky:	Varied from clear to partly cloudly.		
Wind Direction:	Variable	Wind Velocity:	0.9 to 11 mi/hr
Color of Plume:	-	Detached Plume:	No
Interference of Steam Plume:	None		
Duration of Observation:	10/10/73 - 7 hrs. 10/14/73 - 5 3/4 hrs.		

Summary of Data:

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity		Opacity, Percent	Total Time Equal to or Greater Than Given Opacity	
	Min.	Sec.		Min.	Sec.
0	Emissions were 0 percent opacity throughout the observation periods.		55		
10			60		
15			65		
20			70		
25			75		
30			80		
35			85		
40			90		
45			95		
50			100		

Sketch Showing How Opacity Varied With Time:

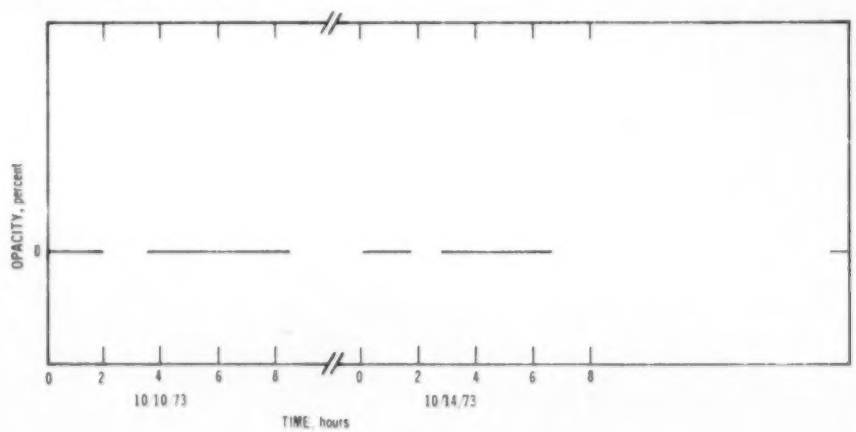


Table 30

FACILITY V

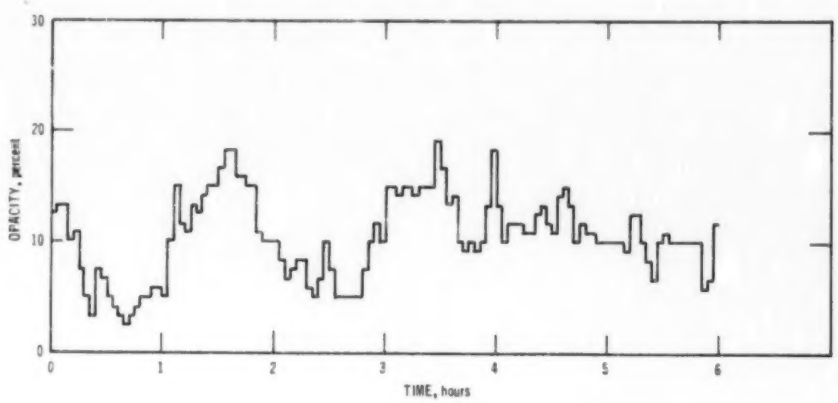
SUMMARY OF VISIBLE EMISSIONS[1]

Date:	2/26/74		
Type of Plant:	Submerged-Arc Silicomanganese Furnace		
Type of Discharge:	Monitor	Distance from Observer to Discharge Point:	~300 ft.
Location of Discharge:	Top of Baghouse	Height of Observation Points:	0 and 20 ft. (2 places used)
Height of Point of Discharge:	~60 ft.	Direction of Observer from Discharge Point:	Southeast
Description of Background:	Sky		
Description of Sky:	Initially overcast, but clear by about 11:30 a.m.		
Wind Direction:	From South	Wind Velocity:	0 to 5 mi/hr
Color of Plume:	Brown	Detached Plume:	No
Interference of Steam Plume:	None		
Duration of Observation:	10:20 a.m. to 4:20 p.m. (360 minutes)		

Summary of Data:

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity		Opacity, Percent	Total Time Equal to or Greater Than Given Opacity	
	Min.	Sec.		Min.	Sec.
0	354	30	55	-	-
10	275	0	60	-	-
15	109	0	65	-	-
20	14	30	70	-	-
25	1	30	75	-	-
30	0	0	80	-	-
35	-	-	85	-	-
40	-	-	90	-	-
45	-	-	95	-	-
50	-	-	100	-	-

Sketch showing how Opacity Varied with Time:[2]



(1) Two observers made simultaneous readings. The greater of their readings was used. Relatively high visible emissions are credited to numerous small leaks in bags.

(2) Average values for 3-minute periods were plotted.

References 13 and 14.

Table 31

FACILITY V

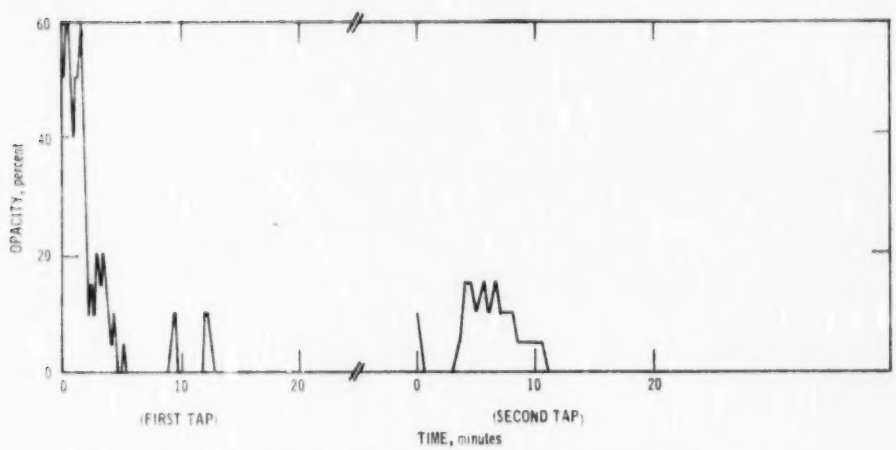
SUMMARY OF VISIBLE EMISSIONS[1]

Date:	2/26/74		
Type of Plant:	Submerged-Arc Silicomanganese Furnace		
Type of Discharge:	Fume escaping Tapping Hood/Distance from Observer to Discharge Point:		40 ft.
Location of Discharge:	Tapping Hood	Height of Observation Point:	0 ft.
Height of Point of Discharge:	5 ft.	Direction of Observer from Discharge Point:	East
Description of Background:	Readings were made inside the furnace building against a background of the furnace and various other surfaces behind the hood.		
Description of Sky:	Not Applicable		
Wind Direction:	None	Wind Velocity:	None
Color of Plume:	Brown	Detached Plume:	No
Interference of Steam Plume:	None		
Duration of Observation:	Two taps of 19 and 30 minutes duration, respectively. Total of 49 minutes of observation.		

Summary of Data:

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity		Opacity, Percent	Total Time Equal to or Greater Than Given Opacity	
	Min.	Sec.		Min.	Sec.
5	14	30	55	0	45
10	10	0	60	0	30
15	5	15	65	0	0
20	2	30	70	-	-
25	2	0	75	-	-
30	2	0	80	-	-
35	2	0	85	-	-
40	2	0	90	-	-
45	1	45	95	-	-
50	1	30	100	-	-

Sketch Showing How Opacity Varied with Time:[2]



[1] Two observers made simultaneous readings. The greater of their readings is reported.

[2] The tap hood was moved aside for the last 45 seconds of the second minute and the first 45 seconds of the 13th minute of the observations during the first tap.

References 13 and 18.

Facility V

Summary of Results

(Visible emissions only)

Visible emissions were read at this facility on February 26, 1974.

Visible emissions from the baghouse monitor did not exceed 25 percent opacity, but visible emissions occurred quite steadily at 5 to 15 percent opacity throughout the 6 hours of readings. These relatively high visible emissions (for a baghouse) are attributed to numerous small leaks in the bags. The baghouse was inspected, and several minor bag leaks were found. Two compartments were quite dusty on the clean side, and a third was noticeably so.

Visible emissions from the roof monitor of the building reached a maximum of 15 percent opacity, but were greater than 0 percent opacity for less than 8 minutes during the six-hour observation.

The furnace hood was observed for about 1 1/2 hours, and furnace hood capture efficiency was consistently estimated as 100 percent.

Two tapping periods were observed, and visible emissions which escaped the tap hood were read. During the first tap period, the hood was moved away twice for unknown reasons; first, for about 45 seconds during the second minute of the tap, and, secondly, for about 45 seconds during the thirteenth minute of the tap. During the first tap, visible emissions escaping the tapping hood ranged from 25 to 60 percent opacity during the first two minutes while the tapping hood was in place. Thereafter, visible

emissions did not exceed 20 percent opacity (one reading) and were 0 percent opacity most of the time. The tapping hood was in place throughout the second tap. During the second tap, maximum visible emissions escaping the tapping hood did not exceed 15 percent opacity, and were 0 percent opacity most of the time.

References 13 and 18.

Table 32

FACILITY W

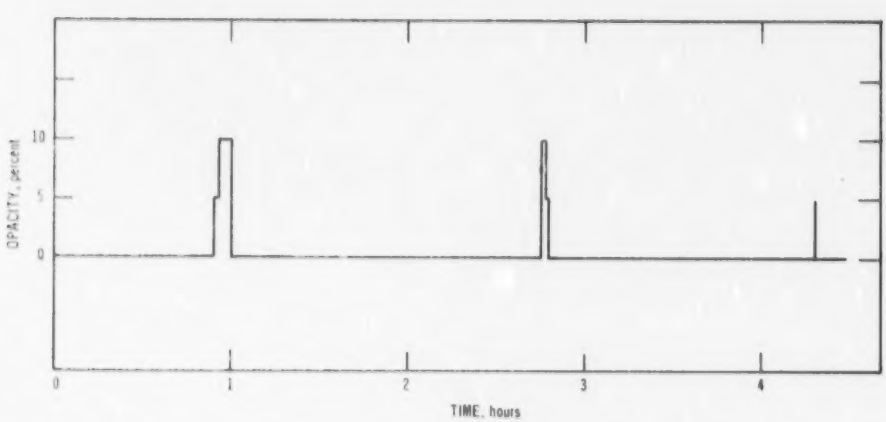
SUMMARY OF VISIBLE EMISSIONS (1)

Date:	2/22/74		
Type of Plant:	Submerged Arc Silicon Metal Furnace		
Type of Discharge:	Monitor	Distance from Observer to Discharge Point:	~500 ft.
Location of Discharge:	Top of Baghouse	Height of Observation Point:	20 ft.
Height of Point of Discharge:	~75 ft.	Direction of Observer from Discharge Point:	South
Description of Background:	Sky		
Description of Sky:	Variable sky conditions ranging from low dark clouds to clear. Some rain ranging from light to heavy. Times when weather conditions prohibited accurate visible emission readings are omitted from this summary.		
Wind Direction:	Varied, from West and North	Wind Velocity:	~15 to 25 mi/hr
		Detached Plume:	No
Color of Plume:	White		
Interference of Steam Plume:	None		
Duration of Observation:	4 hr, 28 min.		

Summary of Data:

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity		Opacity, Percent	Total Time Equal to or Greater Than Given Opacity	
	Min.	Sec.		Min.	Sec.
5	7	30	55	-	-
10	5	30	60	-	-
15	0	0	65	-	-
20	-	-	70	-	-
25	-	-	75	-	-
30	-	-	80	-	-
35	-	-	85	-	-
40	-	-	90	-	-
45	-	-	95	-	-
50	-	-	100	-	-

Sketch Showing How Opacity Varied With Time:



(1) Two observers made simultaneous readings. The greater of their readings is reported.

References 13 and 19.

Facility W

Summary of Results

(Visible emissions only)

Visible emissions were read at this facility on February 22, 1974.

Visible emissions from the baghouse monitor were observed for 6 hours, but during this time, there were several periods when weather conditions, or fume from uncontrolled furnaces made reading visible emissions impossible. During the time readings were possible, visible emissions from the baghouse monitor did not exceed 10 percent opacity and were 0 percent opacity most of the time. When visible emissions did occur, they were localized at one end of the baghouse monitor. On inspection of the baghouse, some leaking bags were observed. Eight bags in two compartments were replaced while the observations were being made.

An uncontrolled furnace existed in the same building as the controlled furnace. Visible emissions from the building roof monitor probably result from tapping the uncontrolled furnace or from pouring of the alloy. Visible emissions from the building monitor were observed at up to 20 percent opacity, but the building monitor was obscurred most of the time by dust from uncontrolled furnaces.

The furnace hood was observed for 30 minutes, and the furnace hood capture efficiency was estimated to be 100 percent.

The tapping hood was observed for part of one tap, and it appeared to achieve complete collection of the tapping fume.

References 13 and 19.

REFERENCES

1. Kelly, Winton E., EPA,"Emissions from Electric-Arc Ferroalloy Furnaces at [Facilities A1, A2, and B]," June, 1973, EMB Project No. 72-PC-15.

2. Emission Test Report for Facilities C and P., prepared for EPA by Resources Research, Inc., Contract No. CPA 70-81. June, 1972. Test No. FA-7.

3. Durkee, Kenneth R., EPA, International Trip Report, "Survey of Japanese Ferroalloy Furnaces," August 9, 1973.

4. Dobryakov, G. G., Serebryakov, M. Z., and Rychkov, V. P., "Operation of a Gas Cleaning System on a Closed Top Electric Furnace," Steel in the U.S.S.R., page 2, May, 1971.

5. "Air Pollution Emission Test, Part I," for Facility K, June, 1974. EMB Report No. 73-FEA-07.

6. Emission Test Report for Facilities L1, L2, and L3., prepared for EPA by Resources Research, Inc., Contract No. CPA 70-81. Test No. FA-2.

7. Emission Test Report for Facility M., prepared for EPA by Resources Research, Inc., Contract No. CPA 70-81, Test No. FA-5.

8. Emission Test Report for Facility N., prepared for EPA by Resources Research, Inc., Contract No. 70-81, Test No. FA-6.

9. "Air Pollution Emission Test" for Facility O, June, 1974. EMB Report No. 73-FEA-5.

10. Emission Test Report for Retest of Facility P, prepared for EPA by TRW Transportation and Environmental Operations, Contract No. 68-02-0235, EMB Test No. 72-PC-14.

11. Emission Test Report for Facility Q, prepared for EPA by Resources Research, Inc., Contract No. 70-81, Test No. FA-3.

12. Seiffert, Randy D., EPA, "Trip Report for Visit to [Facility Q]," March 13, 1974.

13. Letter and attachments from Lawrence Katzman, Walden Research Division of Abcor, Inc., to Randy D. Seiffert, EPA, March 12, 1974.

14. "Air Pollution Emission Test" for Facility R, June, 1974. EMB Report No. 73-FEA-08.

15. "Air Pollution Emission Test" for Facility S, June, 1974. EMB Report No. 73-FEA-09.

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17. "Air Pollution Emission Test" for Facility U, June, 1974. EMB Report No. 73-FEA-10.

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16. ABSTRACT

This volume is the second in a series on the standard of performance for electric submerged arc furnaces producing ferroalloys. This volume summarizes the source test results and visible emission measurements cited in Volume 1. It describes the tested facilities (their operating conditions, characteristics of the exhaust gas streams, and deviations from prescribed test procedures) and summarizes the results of the particulate matter and carbon monoxide tests.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution, Calcium Silicon Pollution Control, Ferromanganese Silicon Standards of Performance, Charge Chrome Ferroalloys, Silicomanganese Zirconium Silicon Metal, High-Carbon Ferrochrome 50% Ferrosilicon, Ferrochrome Silicon, Silvery Iron 65-76% Ferrosilicon, Ferromanganese, Calcium Carbide	Air Pollution Control	

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